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CANADIAN PATENT

⑤④ APPARATUS AND METHOD FOR INVESTMENT COATING
OF PATTERNS

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This invention relates to investment casting.

More particularly, this invention relates to the preparation of improved products by the use of a novel process, and an apparatus suitable for carrying out such a process, according to the present invention.

The investment casting art basically involves the manufacture of a given article in a desired material, (e.g. a ferrous or non-ferrous alloy) by the reproduction of a first or initial pattern of the article made of a disposable material.

10 This initial disposable pattern is coated with one or more different types of refractory material or invested in a solid mold, the coated pattern, or solid mold, being subsequently treated to remove the disposable material with the resulting cavity surrounded by refractory material, being filled with a molten metal (poured into the cavity) and allowed to solidify to reproduce the pattern. These basic steps and other variations are well known to those skilled in this art leading to the production of the final article.

20 At the beginning of the process, a metal mold is normally constructed to permit the reproduction of a plurality of the initial or disposable patterns by techniques known to those skilled in this art. This metal mold contains a precision cavity replicating the final article desired, and the disposable pattern material is introduced into the mold, permitted to solidify or harden, and removed. For each article desired, a disposable pattern will be formed.

30 Conventionally, a number of the disposable patterns are mounted on sprues or runners using gages, both of which are also made of disposable material, the resulting assembly of sprues or runners and patterns being known in the art as a "set-up". The set-up will normally include a pouring cup of disposable material, which functions to permit introduction of the molten metal into the runner system and finally into

the pattern cavities, once the disposable material forming the cup has been coated and removed.

10 To prepare the set-ups for casting of the actual metal patterns, they are provided with one or more refractory coatings according to the well-known ceramic shell molding technique or alternately, invested in a mass of investment material according to the solid mold technique. Following curing and/or hardening of the particular types of refractory material used to coat the set-ups, the disposable material is removed to leave a completely void pattern cavity, and as well, the runners and pouring cup. The particular method of removing the disposable material depends on the type of disposable material employed. For example, in the case of wax, steam de-waxing may be used; in the case of plastic materials, (e.g. polystyrene) firing of the molds at high temperatures is employed, etc. In this respect, it is necessary that the patterns be free from extraneous material since upon pouring of molten metal into the set-up, the patterns have to be reproduced precisely without voids, etc.

20 Following removal of the disposable material, the resulting molds having pattern cavities are then filled with molten metal of a desired type, and the metal permitted to cool and solidify, according to conventional practices. The molds are then broken away leaving the metal patterns on the runners. The patterns are then cut-off the runners and processed according to conventional techniques to result in molded articles of the desired shape.

30 In investment casting procedures, the type of articles and their shape and size may vary considerably; in all cases, however, it is a characteristic of investment casting that the articles produced are precision cast as compared to other casting procedures - e.g. sand molding, where the articles are much

rougher in shape.

One of the critical steps in the production of cast products is the provision of a substantially uniform and continuous coating of investment material on the disposable patterns. In other words, the surface of the cast articles is only as good as the degree of accuracy the coatings of investment material on the patterns permit. If there are air occlusions or if the coating of investment material is porous, the pattern will include minute bubbles or voids which will be reproduced in the cast articles once the disposable material has been removed.

It is well known by those skilled in this art that one of the deficiencies is the failure of investment casting techniques to reproduce articles having very small slots or slits and indicia-bearing products, such as type slug. Attempts at producing these articles, particularly type slug, have resulted in cast products which are at best very unclear and in general, are unacceptable and unuseable.

It has been proposed in the art that when a wax pattern is coated with investment material, special precautions should be employed to prevent occluded air from remaining on the disposable patterns. Thus, in Canadian Patent 719,635, it is taught that disposable patterns should be provided with a first refractory coating, followed by drying of the coating, and subsequent application of an additional coating by dipping the disposable pattern in a slurry and while the disposable pattern is dipped in the slurry, applying a vacuum to the slurry bath. The application of a vacuum to a second stage slurry bath (during application of a second coating of investment material to the pattern) may be suitable for some purposes but it fails to provide a coated disposable pattern, which when the disposable pattern is removed, results in a cast article free from surface occlusions and furthermore, which is incapable

of producing intricate indices. One of the reasons for this is that during application of the initial coating, it is obvious that any air entrapped on the surface of the disposable patterns will be coated with the initial coating of investment material, whereby subsequent coatings such as suggested in Canadian 791,635 will only maintain any occluded air on the surface of the disposable patterns entrapped on the patterns.

More particularly, in accordance with one aspect of the present invention, there is provided a process which overcomes the disadvantages of the prior art and permits, for the first time, the production of investment coated patterns which, when subsequently processed and cast according to conventional techniques, results in precision cast products free from surface occlusions and which are of a high quality. The process of the present invention thus permits, for the first time, the reproduction of disposable patterns having indicia or other similar characters thereon - such as type slug, which heretofore could not be produced by any known method.

The process of the present invention may be carried out by surrounding a set-up having one or more disposable patterns mounted thereon, with a vacuum, and introducing while the set-up is surrounded by the vacuum, an investment coating material. In this manner, it has been found that while introducing the investment material in a vacuum, the investment material will surround the patterns and go into even the smallest cavity or crevice to provide a uniform coating of the investment material about the patterns in such a manner so as to prevent the occlusion of any air on the pattern surfaces.

In a preferred process, the set-up containing or having thereon one or more patterns, is placed in a vacuum chamber and the chamber evacuated, whereafter while the set-up is maintained under vacuum, a slurry of investment material is introduced into the vacuum chamber to completely surround the set-up and to provide a substantially uniform coating of the investment material about the patterns. Thereafter, the vacuum may be released and the slurry of investment material withdrawn from the chamber to leave a coated set-up. If desired, the same process may be subsequently repeated one or more

times to provide additional coatings on the set-up under vacuum, so as to remove occluded or entrapped air from previous coatings.

According to a further aspect of this invention, there is also provided an apparatus for carrying out the above process, which apparatus includes a substantially air-tight retaining chamber adapted to retain a set-up having one or more patterns thereon, and a slurry therein, the chamber being provided with a removable closure means to permit access
10 therein, means for mounting a set-up in the chamber, vacuum means for causing a vacuum in the chamber, means for introducing a slurry into the chamber, means for withdrawing a slurry from the chamber, and means for operating the vacuum means and the means for introducing a slurry into the chamber in time-related sequence whereby the vacuum means creates a vacuum in the chamber, and the means for introducing a slurry is effective to permit introduction of a slurry into the chamber while there is a vacuum in the chamber.

In greater detail, the apparatus of the present
20 invention includes a retaining chamber capable of withstanding negative pressures and which is adapted to retain one or more set-ups having one or more patterns on the set-ups, together with an investment material. The retaining chamber may be of any suitable size and shape, depending on the type of operation and the number of set-ups desired to be coated with an investment material. The retaining chamber may thus be an elongated tank or other similar enclosure. For practical purposes, the chamber will include a removable closure means, such as a port or door to permit access into the interior of
30 the chamber. The port or door may be a removable top closure which is capable of providing an air-tight enclosure with the main body of the chamber. In this respect, the means for mounting a set-up in the chamber may be connected to the

removable closure means or alternately, may include one or more supporting and retaining members mounted in the chamber adapted to suspend one or more set-ups within the chamber.

Depending on the type of retaining chamber employed, as to whether one or more set-ups are to be processed at a single time, the apparatus will include and be of a size sufficient to permit the set-ups to be completely surrounded with a slurry of investment material to a depth sufficient to cover at least the complete set-ups in order to provide
10 a coating of the investment material about the complete set-up. To this end, the capacity of the retaining chamber will vary depending on the size of the set-up and the number of set-ups adapted to be treated according to the process of the present invention.

A further component of the apparatus of the present invention includes vacuum means for causing a vacuum in the chamber. To this end, the vacuum means may be any suitable vacuum pump means capable of creating a vacuum of the desired degree in the chamber. Thus, for example, a suitable type of
20 vacuum pump may be employed connected to the retaining chamber by conduit means, with at least one shut-off valve being preferably employed in the conduit means. In this respect, the conduit means is preferably connected to the retaining chamber at a level above that to which the slurry is located so as to avoid withdrawal of the slurry into the conduit and vacuum means.

The means for introducing the slurry into the chamber may be any suitable conduit adapted to feed a slurry from, for example, a slurry storage tank, into the chamber when the
30 latter has a desired degree of vacuum in it. To this end, such means for introducing the slurry of investment material will include suitable means for permitting and preventing flow of a slurry therethrough so as to control the flow of the

slurry into the chamber as desired. Such means for this purpose may be any suitable valve means. Preferably the same means for introducing the slurry into the chamber also functions as means for withdrawing the slurry from the chamber. In this preferred embodiment and for this purpose, the means for introducing the slurry preferably introduces the slurry into the chamber at a point therein such that when it is desired to withdraw the slurry from the chamber, the slurry can be withdrawn through the same means by gravity. One arrangement accomplishing this, for example, is where the conduit for introducing the slurry into the chamber is located at the bottom of the chamber such that when it is desired to remove the slurry, the slurry may, by gravity, be fed through the same conduit. If maximum slurry withdrawal is desired, the bottom of the container may thus be sloped - i.e. cone-shaped, or otherwise tapered for this purpose.

The apparatus of the present invention is preferably operated in conjunction with slurry retaining means which may comprise a suitable tank or container for retaining a slurry of investment material. To this end, the conduit for introducing the slurry, and withdrawing it, is preferably connected to the slurry retaining tank in such a manner so as to permit constant communication with the slurry only and to avoid withdrawing air from the slurry tank into the retaining chamber. Thus, as with the retaining tank, the conduit for introducing the slurry into the retaining chamber preferably is connected to the bottom or lower portions of the slurry retaining means; it being understood that for this purpose, the amount of slurry in the retaining chamber is always sufficient such that when an amount is withdrawn into the retaining chamber, the conduit connecting the slurry retaining tank and the retaining chamber is not exposed to atmospheric air.

In order to optimize the process, the slurry retained in the slurry retaining means is preferably constantly agitated so as to remove occluded air from the slurry. To this end, any suitable agitation means may be employed - e.g. one or more mixing blades connected to suitable drive means - e.g. a motor. In operation, there are provided means for operating in a time-related sequence, the vacuum means and the means for introducing a slurry into the retaining chamber and as well the means for withdrawing the slurry from the retaining chamber. To this end, such means for operating the apparatus in this sequence may include any suitable means to initially activate the vacuum means so as to create a vacuum in the retaining chamber, and upon a desired vacuum level being created in the chamber, the means for introducing a slurry into the chamber is actuated whereby the slurry is introduced into the chamber under a vacuum to coat the set-up mounted in the chamber. Thereafter, the apparatus is operated so as to remove the vacuum from the chamber which will then, in the preferred embodiment described above, permit the slurry to be removed from the retaining chamber (by gravity) through the same means for introducing the slurry into the retaining chamber.

In carrying out the process of the present invention and having regard to the above preferred apparatus for carrying out such a process, one or more set-ups having one or more patterns thereon are surrounded with a vacuum such as by mounting the set-ups on suitable retaining means in the vacuum retaining chamber, followed by introduction of a slurry of investment material to surround and provide a coating of investment material on the patterns while the latter are exposed to a vacuum. The step of coating the patterns with a slurry of investment material may be carried out for varying lengths of time, depending on the nature of the slurry and the

type of patterns being coated. Normally, however, short periods of time are sufficient so that once the slurry comes in contact with the patterns, - i.e. the patterns are immersed in the slurry, the slurry may then be drained away.

10 The type of slurries of investment material employed for this process may be of any suitable composition well known to those skilled in this art. For the formation of ceramic shell molds, the treatment of the patterns is initially conventionally carried out with one or two "pre-coats" of investment slurries having low viscosities. In the present process, and for patterns having indicia (such as type slag) or patterns having narrow slots, low viscosity slurries - e.g. in the order of from about 1,000 to 2,000 centipoises although higher viscosity slurries may be used, are employed. Typical of the "pre-coat" slurry compositions for building ceramic shell molds are those which include zircon flour, fused silica oxide flour, etc. in liquid carriers such as water-based silica sols, etc.

20 Following coating of the patterns on the set-up(s) in accordance with the process of the present invention, one or more additional coats of the same or similar investment materials may be subsequently applied, followed by the application of one or more refractory coatings of a conventional composition; to build up a shell of the desired thickness. The thickness of the shell will vary depending on many factors well known to those skilled in this art, typical thicknesses being from about one-quarter to one-half inch.

30 In carrying out the vacuum slurry application of investment material to the patterns in the initial step, the degree of vacuum is preferably at a relatively high level - in the order of from 1 to 10 millimeters Hg. In this respect,

the term "vacuum" as used in this disclosure is intended to refer, and denotes, a negative pressure compared to atmospheric pressure and not a vacuum level of 0 mm Hg. Thus, the degree of vacuum will, for most purposes, be within the above range although pressures of up to 20 mm Hg. or more may be employed and still obtain satisfactory results.

Conventional procedures well known to those skilled in this art may be employed following application of the initial coat of investment material to the patterns by the process of the present invention; to this end, if one or more additional coats are applied, sufficient time between coats is provided to permit the previous coat to dry;

Following the formation of a shell of the desired thickness, the material from which the patterns are made - i.e. a disposable material, may then be removed according to conventional techniques - e.g. in the case of wax, the shell molds are dewaxed by the use of steam autoclaves, etc.; following which molten metal (of a desired composition) is then poured into the set-up and patterns. Subsequent processing, upon solidification and cooling of the metal, involves the removal of the shell and cutting-off of the patterns.

Although reference has been made in the above description particularly to the use of the present invention in relation to ceramic shell molds, it is to be understood that the present invention may likewise be advantageously employed in the coating of disposable patterns by the solid mold technique. To this end, the patterns may be initially coated with a slurry as described above and subsequently invested in a mass of investment material to form a solid mold, which may then be processed according to the conventional techniques to yield improved end products having faithful reproductions of the original patterns, which products may

include indicia or other similar markings as well as narrow grooves and slots, which are completely free from surface occlusions.

Having thus generally described the invention, reference will now be made to the accompanying drawings illustrating a preferred embodiment and in which:

FIGURE 1 is a schematic outline of an apparatus suitable for carrying out the process of the present invention;

10 FIGURE 2 is a reproduction of the impression of type slag produced by the investment casting technique using the present invention.

Referring initially to Figure 1, there is schematically illustrated an apparatus suitable for carrying out the present invention, which apparatus includes a slurry storage tank 10 adapted to retain a conventional low-viscosity slurry of investment material. In this respect, for most desirable results, the slurry in tank 10 is continuously agitated by means of a conventional mixing device including a motor 12 and a shaft 14 having mixing blades 16 thereon. In this manner, any occluded air in the slurry is removed prior to actual use of the slurry.

20 The apparatus, in accordance with this invention, includes a retaining chamber indicated generally by reference numeral 18 which is adapted to withstand negative pressures and retain one or more disposable pattern set-ups and a slurry of investment material. In the embodiment illustrated, the chamber 18 is a closed vessel having a removable cover 20 which together with the body of the chamber, forms an air-tight seal.

30 The chamber or vessel 18 is connected to a vacuum source which in this case includes a vacuum pump 22 with a conduit 24 extending therebetween. Mounted on conduit 24 is

a vacuum gauge 26 and a shut-off valve 28.

In the schematic embodiment illustrated, a pair of opposed guide rails 30 are provided for permitting the cover 20 to be raised and lowered. To this end, the cover 20 includes a pair of rigidly connected arms 23, slidably journaled on the tracks or rails 30. A pneumatically operated cylinder 32 is provided, mounted on a supporting frame member 34, the piston 33 of which is connected to the cover 20 by brackets 36, to raise and lower the cover.

10 In the embodiment illustrated, a support shaft 37 is mounted onto cover 20. Shaft 37 serves as a mounting means adapted to retain a disposable set-up indicated generally by reference numeral 38 which is releasably secured thereon by suitable means (not shown). Shaft 34, if desired, may be rotated by suitable means.

20 The chamber or vessel 18 and the slurry retaining tank are connected by suitable means - e.g. a conduit 40 having a shut-off valve 42 therein, and as will be seen, they are arranged so that the slurry in chamber 18 may drain by gravity into the tank 10, as explained hereinbefore. Likewise, the vessel 18 is also provided with conduit 44 having a valve 46 therein for venting the vessel to atmospheric pressure when desired.

30 In carrying out the process of the present invention, and with reference to the above-described apparatus, a disposable set-up having a pattern 38 is mounted on the shaft 34 with the cover and the shaft being lowered into engagement with the chamber 18, (the cover 20 is secured about the chamber 18 in an air-tight manner). Thereafter, a vacuum is created in chamber 18 by operating the vacuum pump 22, so that the level of vacuum is lowered to, for example, 5 - 10 mm Hg. During this operation, the valves 42 and 46 are in a closed position whereby no slurry or atmospheric air is permitted to be introduced into chamber 18.

After the vacuum has reached the desired level, valve 42 is opened to permit the slurry to discharge from slurry tank 10, through conduit 40, into chamber 18 due to the difference in the levels of pressure between the two tanks or chambers. During introduction of the slurry into the chamber 18, the vacuum is maintained in the chamber 18 since the slurry is taken from the bottom of the tank 10 so that atmospheric pressure cannot be introduced into the chamber 18. In this manner, the initial coating of the slurry on the disposable set-up 38 is provided under vacuum, whereby there cannot be any occluded air on the disposable patterns.

Following introduction of the slurry into the chamber 18, to a level sufficient to cover substantially completely the set-up 38, the vacuum in chamber 18 is released by opening valve 46 and the slurry is permitted to drain, by gravity, back into tank 10. Thereafter, the valves 42 and 46 are closed and the process repeated with additional set-ups. Alternately, as explained hereinbefore, following drying of set-up 38, second or subsequent coats may be processed as described above.

The above-described apparatus and process were employed to treat and provide an initial coating of an investment material onto disposable set-ups 38 which included disposable patterns of type slag, and patterns having other indicia on their surfaces. Following processing, as described above, and by subsequent formation of a refractory ceramic shell about the disposable patterns, the patterns were then removed by conventional techniques and cast with molten metal. The metal was permitted to cool and the shells removed from the resulting product. The type slag reproduced by such a process was used to imprint impressions using conventional inks. Certain of the impressions resulting from type slag produced according to the present invention are illustrated in Figure 2, from which it will be noted that even the most difficult characters, namely the percentage sign (%) and as well the dollar sign (\$) can be reproduced with an extremely

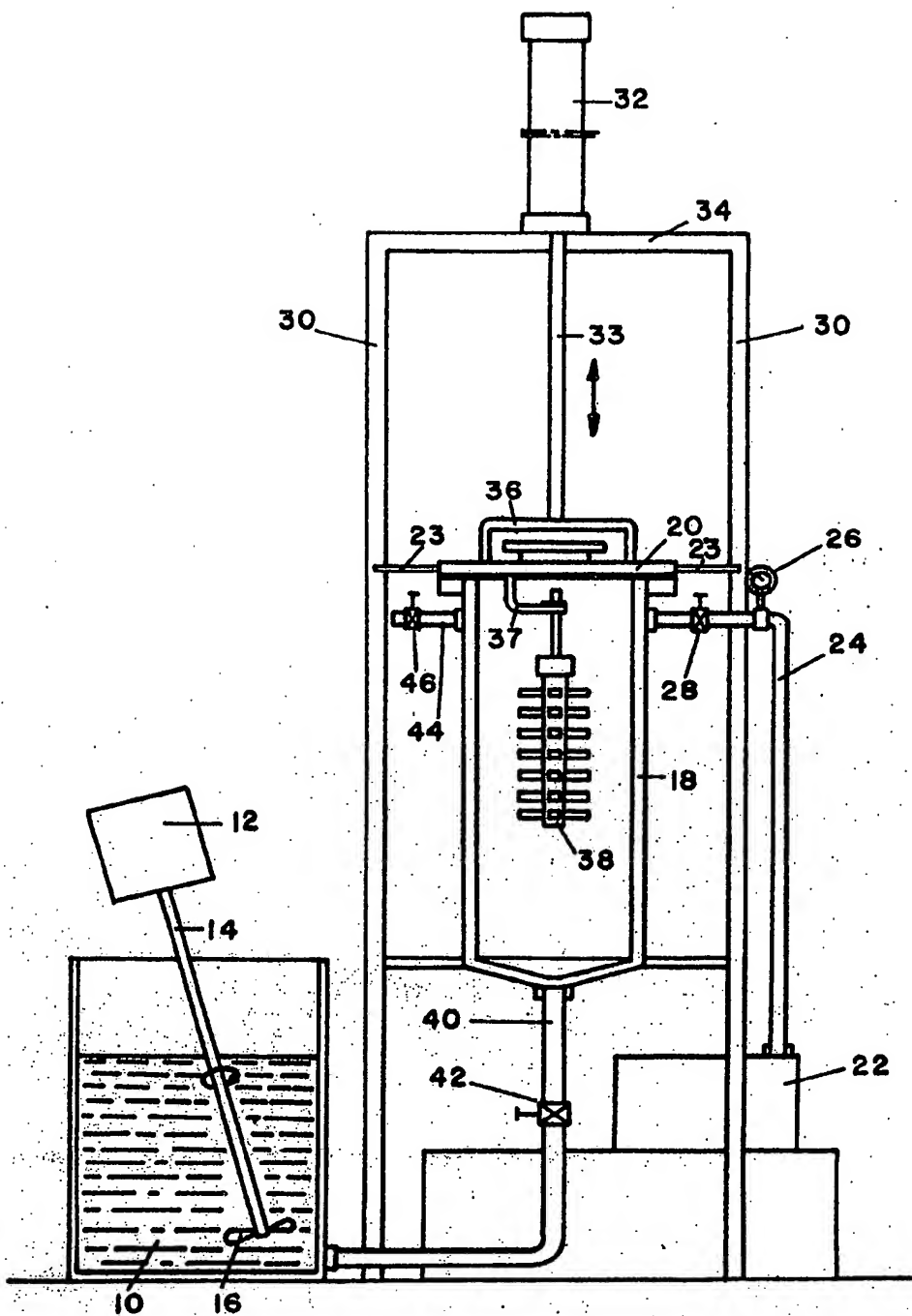
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high accuracy and clarity. A study of the type slag indicated that its quality was substantially equal to type slag produced by other conventional type-slag-producing procedures. Thus, with the present invention, there is provided for the first time an investment casting process which is capable of producing intricate patterns which are of a quality at least equal to those patterns produced by other more expensive processes.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a casting produced by the investment casting process, the improvement wherein the casting has been prepared using the improvement of initially coating the disposable pattern making up the casting, while the pattern is maintained under a vacuum, and thereafter coating the disposable pattern with one or more coats of refractory material to produce a casting free from imperfections due to air occlusions on the disposable pattern.
2. A product of claim 1 wherein the casting is type slag.



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